Claims:

1. An end effector adapted to grip a peripheral edge of a workpiece, comprising:

a workpiece blade for supporting a workpiece;

a first and second gripper arm operatively mounted to said workpiece blade, said first and second gripper arms including a contact pad;

means for moving said first and second gripper arms between a workpiece-loading position and a workpiece-engaging position where said contact pads contact the peripheral edge of the workpiece and exert a force on the workpiece; and

means for dynamically adjusting the force exerted on the workpiece while said first and second gripper arms are located in said workpiece-engaging position.

2. The end effector according to claim 1, wherein said contact pads contact the peripheral edge of the workpiece.

3. The end effector according to claim 1, wherein said first and second gripper arms further include a force sensing device adapted to measure the force said contact pads exert on the workpiece.

4. The end effector according to claim 1, wherein said contact pads further include sensors adapted to detect the edge of the workpiece.

5. The end effector according to claim 4, wherein said sensors comprise thru-beam sensors.

6. The end effector according to claim 1, wherein said means for moving said first and second gripper arms comprises a motor assembly that is operatively coupled with said first and second gripper arms.

7. The end effector according to claim 6, wherein said motor assembly includes:

a brushless motor having an output shaft;

a planetary gear having a first end coupled to said output shaft and a second end having a shaft extending outward from said planetary gear that rotates slower than said output shaft;

a cam coupled to said shaft, said cam having a geometrical center that is offset from the rotational center of said shaft;

a carriage having a drive slot adapted to receive said cam; and

a flexible link having a central portion adapted to secure to said carriage, a first and end adapted to secure to said first gripper arm, and a second end adapted to secure to said second gripper arm.

8. The end effector according to claim 7, further comprising a real-time force feedback system, including:

a force sensing device secured to each one of said contact pads, each force sensing device adapted to generate an electrical signal representing the amount of force being exerted against the workpiece; and

a processor adapted to receive said electrical signal from each said force sensing device and sending an electrical signal to said brushless motor in order to adjust the position of said first and second gripper arms.

9. An end effector adapted to grip a peripheral edge of a workpiece, comprising:

a workpiece blade for supporting a workpiece;

a plunger device adapted to move linearly between a workpiece-loading position and a workpiece-engaging position where said plunger device contacts the peripheral edge of the workpiece and exerts a force on the workpiece;

means for moving said plunger device between said workpiece-loading position and said workpiece-engaging position; and

means for dynamically adjusting the force said plunger device exerts on the workpiece while said plunger device is located in said workpiece-engaging position.

10. The end effector according to claim 9, wherein said plunger device has a distal end including a plurality of spaced apart contact pads.

11. The end effector according to claim 10, wherein each one of said plurality of contact pads contacts the peripheral edge of the workpiece.

12. The end effector according to claim 11, wherein each one of said plurality of contact pads includes a sensor array adapted to detect an edge of the workpiece before said contact pad contacts the peripheral edge of the workpiece.

13. The end effector according to claim 10, wherein said plunger device further includes a force sensing device adapted to measure the force said contact pads exert on the workpiece.

14. The end effector according to claim 12, wherein said sensors comprise thru-beam sensors.

15. The end effector according to claim 1, wherein said means for moving said plunger device comprises a motor assembly that is operatively coupled with said plunger device.

16. The end effector according to claim 9, further comprising a real-time force feedback system, including:

a force sensing device secured to each one of said contact pads, each force sensing device adapted to generate an electrical signal representing the amount of force being exerted against the workpiece; and

a processor adapted to receive said electrical signal from each said force sensing device and sending an electrical signal to said brushless motor in order to adjust the position of said plunger device.

17. An apparatus for handling wafers, comprising:

a wafer blade for supporting a wafer;

a first and second contact arm operatively mounted to said wafer blade, said first and second contact arms each having a contact pad adapted to contact a peripheral edge of the wafer;

a motor assembly operatively connected to said first and second contact arms, said motor assembly for moving said first and second contact arms between a wafer-loading position that allows a wafer to be loaded onto said wafer blade and a wafer-engaging position where each said contact pad contacts the peripheral edge of the wafer and exerts a force on the wafer;

a force sensing device adapted to measure the amount of force each said contact pad exerts against the peripheral edge of the wafer; and

a force feedback system electrically coupled to each said force sensing device and said motor assembly, said force feedback system adapted to control the operation of said motor assembly based on the amount of force measured by said force sensing device.

18. The apparatus according to claim 17, wherein said force sensing device measures the force said contact pads exert on the wafer in real-time.

19. The apparatus according to claim 17, wherein each said contact pad further includes sensors adapted to detect the edge of the wafer before said contact pad contacts the peripheral edge of the wafer.

20. The apparatus according to claim 17, wherein said force sensing device comprises a load cell.

21. The apparatus according to claim 17, wherein said force sensing device comprises a strain gauge.

22. An apparatus for handling wafers, comprising:

a wafer blade for supporting a wafer;

a plunger device having a contact pad adapted to contact a peripheral edge of the wafer and a force sensing device for monitoring the amount of force said contact pad exerts on the peripheral edge of the wafer;

a drive assembly operatively connected to said plunger device, said drive assembly adapted to move said plunger device between a wafer-loading position and a wafer-engaging position; and

a force feedback system electrically coupled to said force sensing device and said drive assembly, said force feedback system adapted to control the operation of said drive assembly based on the force monitored by said force sensing device.

23. The apparatus according to claim 22, wherein each one of said plurality of contact pads includes sensors for detecting the edge of a wafer before said plurality of contact pads contact the peripheral edge of the wafer.

24. An end effector adapted to contact a peripheral edge of a wafer, comprising:

a wafer blade for supporting a wafer;

a contact mechanism operatively connected to said wafer blade and adapted to travel between a wafer-loading position and a wafer-engaging position, said contact mechanism having at least one contact pad adapted to contact the peripheral edge of the wafer when said contact mechanism is located in said wafer-engaging position and a force sensing device adapted to measure the force said contact pad exerts on the wafer;

a carriage operatively connected to said contact mechanism, said carriage adapted to travel along a linear path between a first position that places said contact mechanism in said wafer-loading position and a second position that places said contact mechanism in said wafer-engaging position;

a motor assembly operatively coupled with said carriage, said motor assembly adapted to drive said carriage between said first position and said second position; and

a force feedback system electrically coupled to said force sensing device and said motor assembly, said force feedback system adapted to control the operation of said motor assembly based on the force measured by said force sensing device.

25. The end effector according to claim 24, wherein said contact mechanism comprises a first and second gripper arm.

26. The end effector according to claim 25, wherein said first and second gripper arms are rotatably mounted on said wafer blade.

27. The end effector according to claim 24, wherein said contact mechanism comprises a plunger device.

28. The end effector according to claim 24, wherein each one of said plurality of contacts pads includes sensors adapted to detect the edge of the wafer before said plurality of contact pads contacts the peripheral edge of the wafer.

29. An end effector adapted to grip a peripheral edge of a wafer, comprising:

a wafer blade for supporting a wafer;

a gripping mechanism operatively coupled with said wafer blade, said gripping mechanism having a contact area adapted to contact the peripheral edge of the wafer; and

an actuator for moving said contact area between a wafer-loading and a wafer-engaging position, said actuator adapted to hold said contact area in any number of predetermined positions located between said wafer-loading position and said wafer-engaging position.

30. The end effector according to claim 29, wherein said gripping mechanism comprises a first gripper arm having a contact area and a second gripper arm having a contact area.

31. The end effector according to claim 29, wherein said actuator is adapted to move said first and second gripper arms between said wafer-loading position and said wafer-

engaging position and hold said first and second gripper arms in any number of predetermined positions located between said wafer-loading position and said wafer-engaging position.

32. The end effector according to claim 30, wherein said contact area of said first and second gripper arms contacts the peripheral edge of the wafer when said first and second gripper arms are located in said wafer-engaging position.

33. The end effector according to claim 29, wherein said gripping mechanism comprises a plunger device having a contact area.

34. The end effector according to claim 33, wherein said actuator is adapted to move said plunger device between said wafer-loading position and said wafer-engaging position and hold said plunger device in any number of predetermined positions located between said wafer-loading position and said wafer-engaging position.

35. The end effector according to claim 34, wherein said contact area of said plunger device contacts the peripheral edge of the wafer when said plunger device is located in said wafer-engaging position.